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Enhancing Performance Mesh Networks by Utilizing Excess Capacity

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Abstract- Wireless mesh networks (WMNs) have gained considerable interest in expanding IEEE 802.11 networks to large-scale enterprise and community scenarios, primarily because of its capability of providing wide-band network access to a significant number of users. However, the mesh nodes are typically limited in resources such as bandwidth, computation power and memory. Capacity limitation is one of the fundamental issues in wireless networks. Excess capacity(EC) is the unused capacity. Here in this paper EC Management techniques are used to improve network performance. In this approach a proactive provisioning algorithm is used which is checking in advance whether network capacity is full or not, whether new more connections can be established or not and is freeing up the excess capacity in advance. This approach reduces the End-to-End delay, packet lost ratio and improves the other network performance metrics like packet delivery ratio, throughput and capacity utilization. These process is performed by reserving capacity and freeing up the excess capacity respectively in advance.

Index Terms- Capacity Utilization, *E*xcess Capacity(EC), Provisioning, Packet Delivery Ratio, Throughput, End-to-End Delay

I. Introduction

A wireless network refers to any network not connected by cables, which enables desired convenience and mobility for the user. Routers do not have enough knowledge of end-to-end traffic to make informed decisions on which path each packet should take. In many cases operators have enhanced their ability to manage traffic by extracting additional information per-packet, by looking beyond the network header, and per-flow, by reconstructing data streams over time, both of which ingrain protocol specific behavior into the network. In A connection-oriented mesh network such as a telecom backbone network, a traffic demand is typically satisfied by provisioning a primary path, and higher service availability is provided by provisioning a backup path to protect the resources used in the primary path. The network resource utilization varies both spatially and temporally as new connections are set up and existing connections terminate. Hence, at any given time, whenever a network has some unused capacity, then it is called as excess capacity (EC).

EC Management techniques improves network performance metrics like Packet Delivery Ratio, Throughput, End-to-End delay, Packet Lost Ratio, Capacity Utilization rate. Packet delivery ratio is the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination. Throughput refers to how much data can be transferred from one location to another in a given amount of time. End-to-end Delay is the average time taken by a data packet to arrive to the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted. Packet Lost is the total number of packets dropped during the simulation. Capacity Utilization Rate is a metric used to measure the rate at which potential output levels are being met or used. Capacity Utilization level give insight into the overall slack at a given point in time.

II. EXISTING SYSTEM

In the existing system Lazy Approach was used which migrates Connections only when necessary i.e., it is not checking in advance whether network capacity is full or not, whether new connections can be established or not and is not making any effort to free up the EC in advance. The flowchart in the Fig.1 shows the admission process of Lazy Approach[1]. In the Lazy approach when a new connection request arrives, it checks for the availability of primary path. If a path is found the connection gets established else Reprovisioning and pre-provisioning is done. If it is successful connection gets established else SLP Reprovision and Preprovision is done. If it also fails network is upgraded.

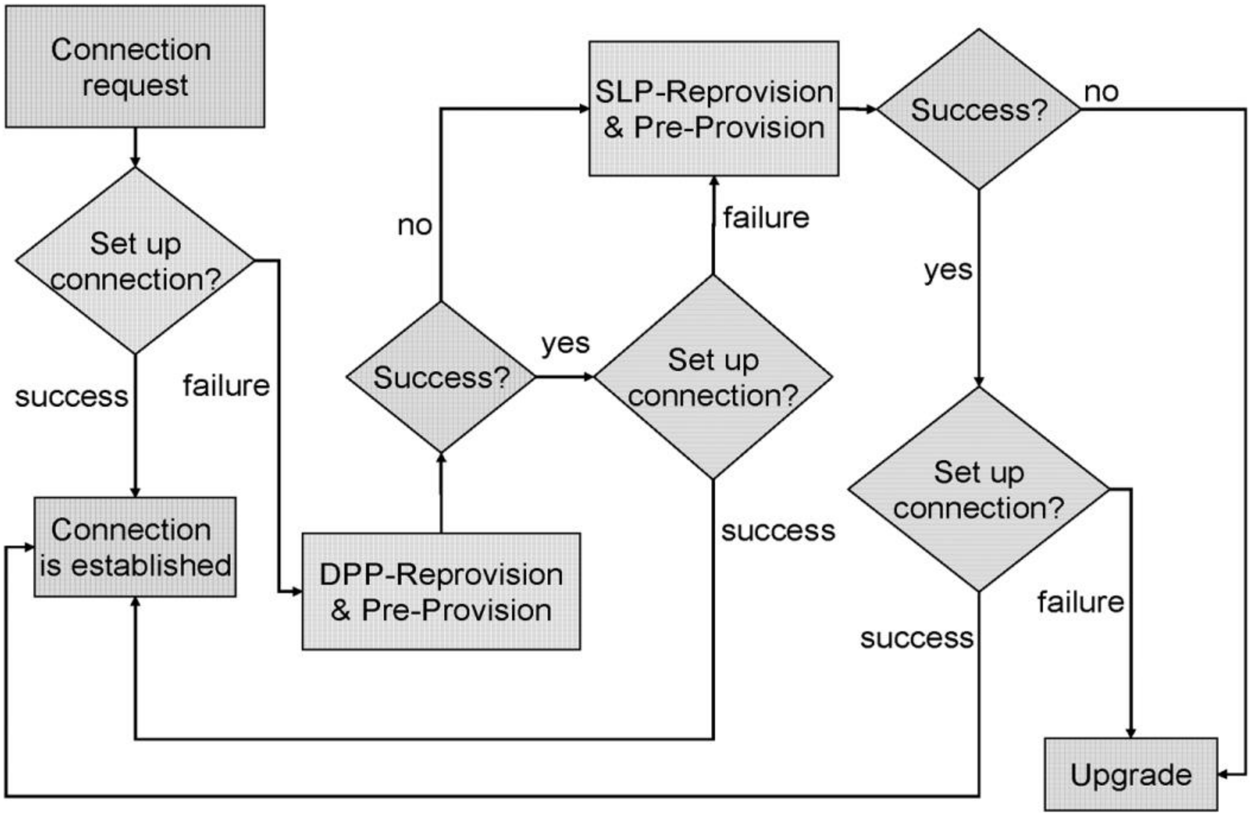

Fig.1 Flowchart for Admission Process of Lazy Approach

If there are more number of connection requests, new connection cannot be established and the network gets blocked. In the Lazy Approach the network performance metrics are not up to the mark and Partial Backup Reprovisioning Techniques[1] are used to improve the network performance.

To overcome the dis-advantage of above system we are going for ProActive Preprovisioning Algorithm which is proactively checking whether the network capacity is full or not, whether new connections can be established or not and is making an effort to free up the EC in advance. It improves the network performance metrics like packet Delivery Ratio, Throughput, End-to-End delay, Packet lost ratio and Capacity utilization Rate.

III. MANAGING EXCESS CAPACITY

EC Management problem is dynamic. Usually network state changes when one of the following event occurs

i. When a new connection request arrives
ii. When an existing connection terminates
iii. When a network failure occurs
iv. A failed link/node is repaired and
v. Can be when the network is upgraded

Usually Connection Requests arrives, they hold for a while and terminate. So, the traffic load and the amount of EC fluctuates. When traffic increases network resources might soon get exhausted due to high capacity requirement. To solve this problem more capacity efficient schemes are used.

A .Modeling the Problem

Here, in this paper a mesh network with some desired wavelength per link in each direction is considered. Node formation is the first step for making a network communication in which any node can be of anywhere. Nodes are mobile in nature. The connections between these nodes are wireless. Since we are dealing with Wireless Sensor Networks , all nodes can communicate with each other as the entire nodes in the network are mobile nodes.

The data I am using as input to the system is daily fluctuating traffic models and their connection requests arrival rates dependent on time of the day i.e., the time at which traffic rate or network capacity is high and at what time network capacity is less.

Now consider a graph [shown in Fig. 2] which shows fluctuations of number of connection requests over a day period. I am dividing a 24-hour time period into three time intervals: 00:00 AM to 06:00 AM, 06:01 AM to 10:00 AM, 10:00 AM to 11:59 PM of a particular day. So, the connection request arrival rates are input to the system. Connection request arrival rates of these time intervals are considered to be A1,A2,A3 respectively.

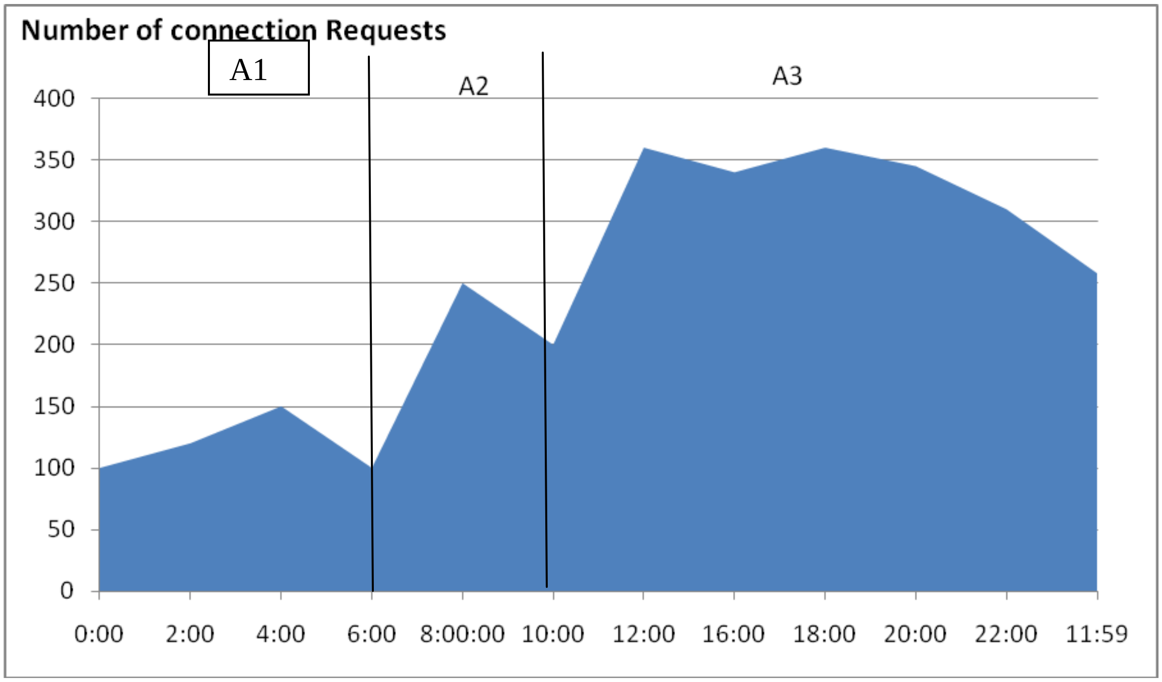

Fig.2 Fluctuations of Number of connection Request Arrival rates

From the Fig. 2, connection request arrival rates are determined in such a way that traffic load is high in third interval and low in the first interval. This fluctuations are taken from the Internet survey, where the number of internet users will be less during 00:00 AM to 06:00 AM, number of internet users are more during 06:01 AM to 10:00 AM, and it follows positive exponential i.e., the number of internet users start increasing from 10:00 AM to 11:59 PM.

B. EC-AWARE PROACTIVE PREPROVISIONING

In the previous scenarios Lazy Approach [1] was used which migrates connections only when necessary. Lazy Approach is not checking in advance whether any more new connections can be established or not, whether network capacity is full or not and is not making any effort to free up the excess capacity in advance.

In this paper, *ProActive Preprovisioning technique* is used to free up capacity in advance or free up the network connections before the capacity exhaustion. Provisioning is the process of preparing a network to allow services to its users. Pre-provisioning allow to pre-configure the interfaces before providing services to its users. The ProActive Preprovisioning technique [shown in Fig. 3] works as follows. After the node formation and topology creation, whenever a new request arrives it checks for the availability of primary path. If a primary path is not available network is upgraded. If a primary path is available for a particular request, a connection is established. After the establishment of connection it calculates the updated cost of the link C(E), [Initially C(E)=0], finds failure link and finds best link by using *Proactive Preprovisioning Algorithm*.

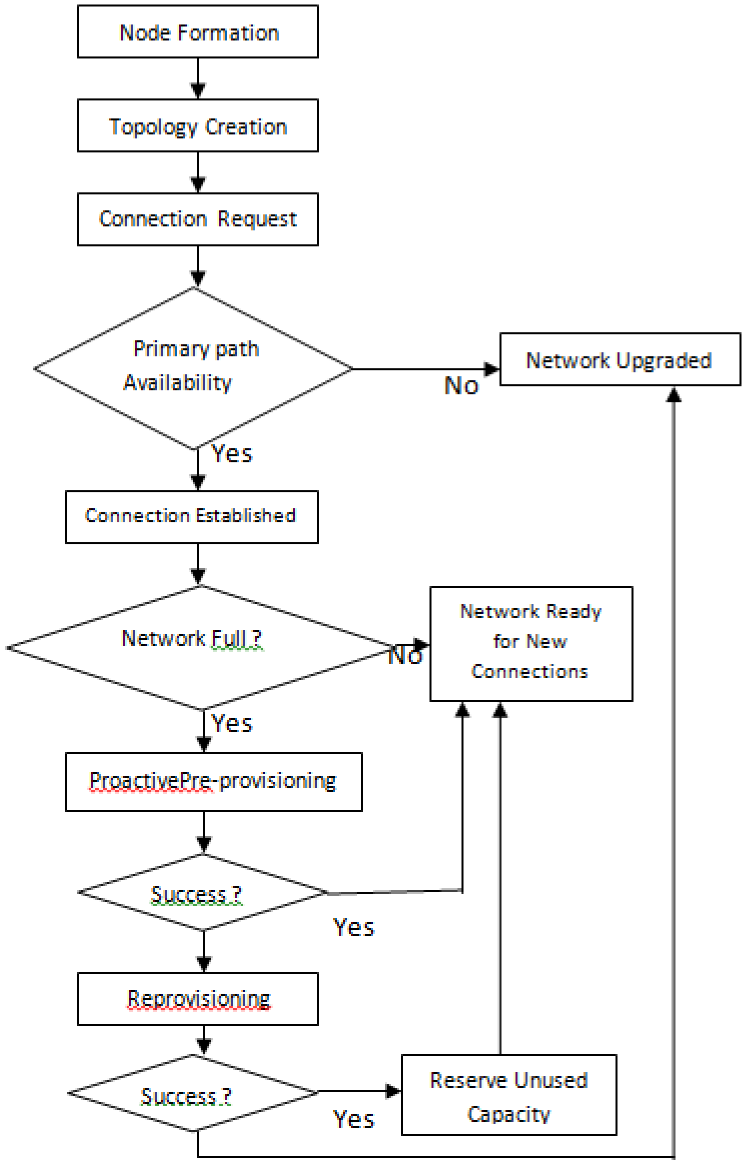

Fig. 3 Flowchart for Proactive Preprovisioning

If C(E) ≠ ∞, it means network is ready for new connections. If C(E) = ∞ it means network is full and no more new connections can be established. Cost of the Link C(E) is calculated as the difference between the number of wavelengths on link 'e' and the number of free(excess) wavelengths on a particular link 'e'. After calculating the cost of the link, select a link with the maximum cost and choose a free wavelength 'w' on 'e'. Compute a backup path for wavelength on 'e' by using a two step algorithm[4] by using cost function C(E). If C(E) = ∞, it means network is full and no more connections can be established. In this case network is flagged as saturated(A link is said to reach a saturation point when all the wavelengths on the link are either used or reserved, or there are not enough resources to reserve a backup path or to establish a new connection) and *Reprovisioning* is performed to free some EC in advance. If C(E) does not meets the EC condition then that capacity is reserved in advance for future use. If Proactive Reprovisioning is successful then network is ready for new connections, else network is upgraded. Capacity of the link is calculated by Shanon Hartley equation[22] which is given by

$$C = B\log_2\left(1+\frac{S}{N}\right)$$

where

C is the channel capacity in bits per second;
B is the bandwidth of the channel in hertz (passband bandwidth in case of a modulated signal);
S is the average received signal power over the bandwidth (in case of a modulated signal, often denoted *C*, i.e. modulated carrier), measured in watts (or volts squared);
N is the average noise or interference power over the bandwidth, measured in watts (or volts squared); and

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S/N is the signal-to-noise ratio (SNR) or the carrier-to-noise ratio (CNR) of the communication signal to the Gaussian noise interference expressed as a linear power ratio (not as logarithmic decibels).

TABLE I. NOTATIONS

[1] C(e)	[2] Cost of link e
[3] W(e)	[4] Number of wavelengths on link e
[5] F(e)	[6] Number of free(excess) wavelengths on link e
[7] R(e)	[8] Number of reserved wavelengths for primary on link e

Algorithm 1: Proactive Preprovisioning

1. Update Cost of the Links, C(E) = W(E) – F(E), if F(E) = 0, then C(E) = ∞.
2. Take a maximum-Cost-Link on 'e' and choose a free wavelength 'w' on 'e'.
3. Compute a backup path for wavelength of 'e' with two step algorithm[4] by using cost function C(E).
4. If C(E) = ∞, no more new connections can be established. Go to Step.(6).
5. If C(E) ≠ ∞, network is ready for new connections and reserve capacity R(E) for future use.
6. Check for free wavelengths F(E), Reserved wavelengths R(E). If available use for new connection request.
7. Update Cost of the Link C(E)= W(E) – R(E). If R(E)=0, then C(E) = ∞.

IV. EXPERIMENTAL RESULTS

Here performance is measured using network performance metrics and is compared with the Lazy Approach[1]. The performance metrics are Packet delivery Ratio, Throughput, End-to-End delay, packet Lost Ratio and Capacity Utilization

A. Packet Delivery Ratio

Packet delivery ratio is the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination. The greater value of packet delivery ratio means the better performance of the protocol.

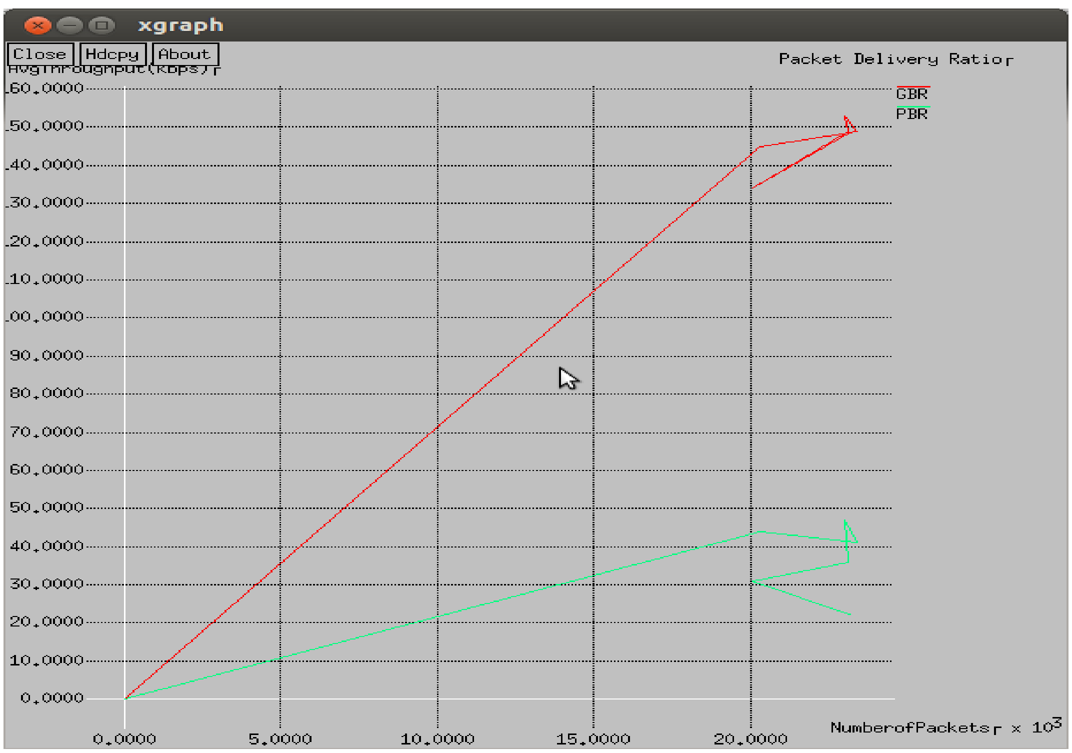

Fig.4 xgraph for Packet Delivery Ratio

In the above graph red line indicates our proposed proactive preprovisioning or Global preprovisioning(GBR), and green line indicates the existing partial bacup reprovisioning(PBR) technique. Packet Delivery Ratio is high for GBR when compared to PBR.

B. End-to-End Delay

End-to-end Delay is the average time taken by a data packet to arrive in the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted.

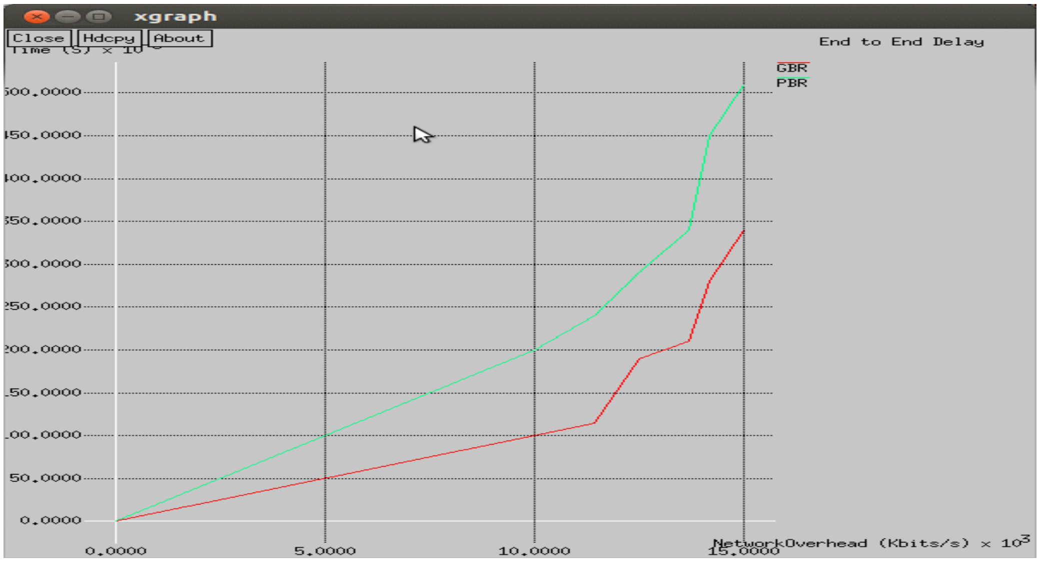

Fig.5 xgraph for End-to-End Delay

The lower value of end to end delay means the better performance of the protocol.*The above results in the xgraph shows End-to-End delay is less for GBR(Red line) when compared to PBR(Green line).*

C. Number of Packets Lost

Packet Lost is the total number of packets dropped during the simulation. The lower value of the packet lost means the better performance of the protocol. Total number of packets dropped are less for GBR(Red line) when compared to PBR(Green line).

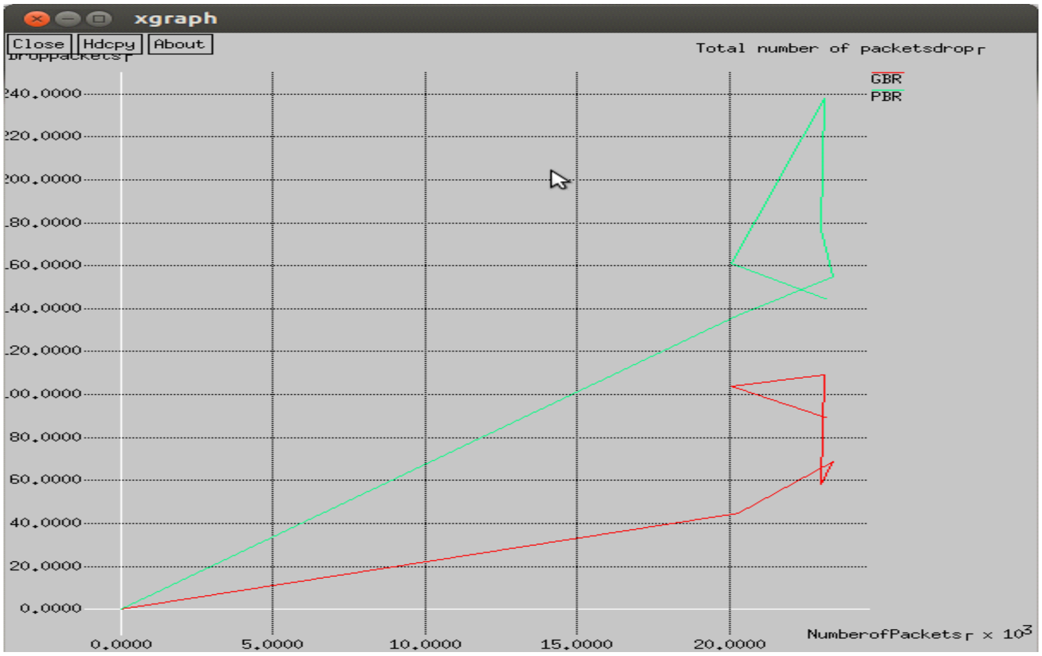

Fig.6 xgraph for Packet Lost Ratio

D. Trace File Generation

Trace file generation shows at what time the packets are moved from one node to other. How many packets are dropped while transmitting the data from source to destination, how many packets arrived successfully to destination, how many packets are departed in queue and how many packets have departed from one node to other node.

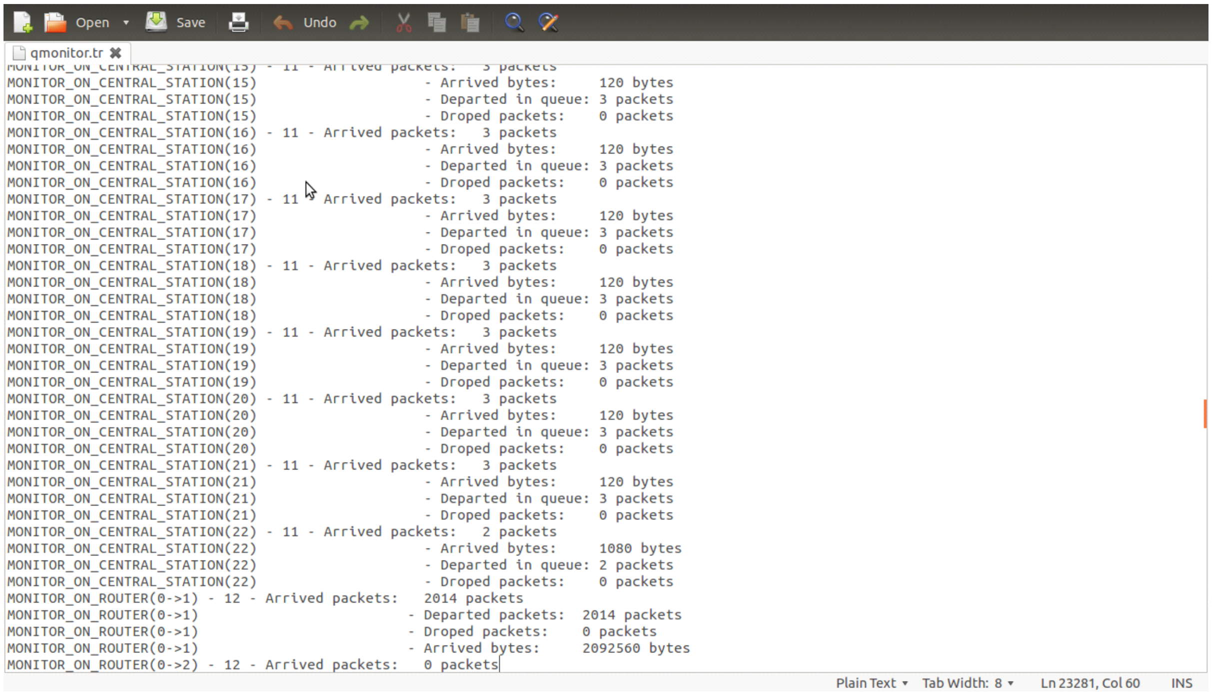

Fig.7 Trace File Generation

V. CONCLUSION

The capacity utilization in a network may fluctuate in time. When the traffic load is low, excess capacity can be exploited to provide better services to customers. When plenty of excess capacity is available, protecting connections is advisable because of its protection switching time, highest availability and packet delivery ratio compared to other protection schemes. In the proposed System proactive approach is defined which identifies the nodes with excess capacity, and migrates all connections when necessary. The main advantage of using proactive approach is, it overcomes the problem of Lazy approach which is not checking in advance whether new connections can be established or not, whether network capacity is full or not and is not making any effort to free up the excess capacity in advance. Then we compute the result analysis of network performance metrics like End-to-End delay, packet delivery ratio, throughput, number of packets lost during transmission which shows better results than existing system.

This proposed technique provides the best results in resource utilization, throughput, packet delivery ratio and energy. My future plans include exploring new areas of research in wireless networks, and extending my research in capacity enhancement and network reliability. In future I decided to improve the more resource utilization process and also planned to make the best results in packet delivery ratio, throughput and energy level.

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